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1. GENERAL BACKGROUND INFORMATION

ACRONYMS AND ABBREVIATIONS USED IN THIS BULLETIN

BIPM - Bureau International des Poids et Mesures
CCIR - International Radio Consultative Committee
Cs - Cesium standard
GOES - Geostationary Operational Environmental Satellite
GPS - Global Positioning System
IERS - International Earth Rotation Service
LORAN - Long Range Navigation
MC - Master Clock
MJD - Modified Julian Date
NVLAP - National Voluntary Laboratory Accreditation Program
NIST - National Institute of Standards and Technology
NOAA - National Oceanic and Atmospheric Administration
SI - International System of Units
TA - Atomic Time
TAI - International Atomic Time
USNO - United States Naval Observatory
UTC - Coordinated Universal Time
VLF - very low frequency

ns - nanosecond
µs - microsecond
ms - millisecond
s - second
min - minute

2. TIME-SCALE INFORMATION

The values listed below are based on data from the IERS, the USNO, and NIST. The UTC(USNO,MC) ~ UTC(NIST) values are averaged measurements from up to approximately 10 GPS satellites (see bibliography on page 5). **UTC-UTC(NIST) data are on page 3.**

0000 HOURS COORDINATED UNIVERSAL TIME			
JAN 2003	MJD	UT1–UTC(NIST) (±5 ms)	UTC(USNO,MC)–UTC(NIST) (±20 ns)
2	52641	–289 ms	8 ns
9	52648	–294 ms	8 ns
16	52655	–299 ms	8 ns
23	52662	–302 ms	9 ns
30	52669	–306 ms	9 ns

The master clock pulses used by the WWV, WWVH, WWVB, and GOES time-code transmissions are referenced to the UTC(NIST) time scale. Occasionally, 1 s is added to the UTC time scale. This second is called a leap second. Its purpose is to keep the UTC time scale within ±0.9 s of the UT1 astronomical time scale, which changes slightly due to variations in the rate of rotation of the Earth.

NOTE: NO positive leap second will be inserted at the end of June 2003.

Positive leap seconds, beginning at 23 h 59 min 60 s UTC and ending at 0 h 0 min 0 s UTC, were inserted in the UTC timescale on 30 June 1972, 1981-1983, 1985, 1992, 1993, 1994, and 1997, and on 31 December 1972-1979, 1987, 1989, 1990,1995, and 1998. There have been 22 leap seconds inserted in total.

The use of leap seconds ensures that UT1 ~ UTC will always be held within ±0.9 s. The current value of UT1- UTC is called the DUT1 correction. DUT1 corrections are broadcast by WWV, WWVH, WWVB, and GOES and are printed below. These corrections may be added to received UTC time signals in order to obtain UT1.

DUT1 = UT1 – UTC +

+0.1 s beginning 0000 UTC 19 October 2000
+0.0 s beginning 0000 UTC 01 March 2001
–0.1 s beginning 0000 UTC 04 October 2001
–0.2 s beginning 0000 UTC 14 February 2002
–0.3 s beginning 0000 UTC 24 October 2002

The deviation of UTC(NIST) from UTC has been within +/−100 ns since July 6, 1994. The table below shows values of UTC - UTC(NIST) as supplied by the BIPM in their Circular T publication for the most recent 300-day period in which data are available. Data are given at ten day intervals. Five day interval data are available in Circular T.

0000 Hours Coordinated Universal Time

DATE	MJD	UTC-UTC(NIST) ns
Dec. 31, 2002	52639	−2
Dec. 21, 2002	52629	−3
Dec. 11, 2002	52619	−4
Dec. 1, 2002	52609	−3
Nov. 22, 2002	52599	2
Nov. 12, 2002	52589	3
Nov. 2, 2002	52579	4
Oct. 22, 2002	52569	5
Oct. 12, 2002	52559	4
Oct. 2, 2002	52549	4
Sept. 22, 2002	52539	3
Sept. 12, 2002	52529	0
Sept. 2, 2002	52519	−1
Aug. 23, 2002	52509	−6
Aug. 13, 2002	52499	−13
Aug. 3, 2002	52489	−11
July 24, 2002	52479	−4
July 14, 2002	52469	0
July 4, 2002	52459	3
June 24, 2002	52449	8
June 14, 2002	52439	12
June 4, 2002	52429	11
May 25, 2002	52419	12
May 15, 2002	52409	14
May 5, 2002	52399	0
Apr. 25, 2002	52389	−2
Apr. 15, 2002	52379	−7
Apr. 5, 2002	52369	−1 4
Mar. 26, 2002	52359	−1 5
Mar. 16, 2002	52349	−1 3
Mar. 6, 2002	52339	−9

3. PHASE DEVIATIONS FOR WWVB AND LORAN-C

WWVB - The values shown for WWVB are the time differences between the time markers of the UTC(NIST) time scale and the first positive-going zero voltage crossover measured at the transmitting antenna. The uncertainty of the individual measurements is ±0.5 µs. The values listed are for 1300 UTC.

LORAN-C - The values shown for Loran-C represent the daily accumulated phase shift (in ns). The phase shift is measured by comparing the output of a Loran receiver to the UTC(NIST) time scale for a period of 24 h. If data were not recorded on a particular day, the lone symbol (-) is printed. The stations monitored are Baudette, ND (8970-Y) and Fallon, NV (9940). The monitoring is done from the NIST laboratories in Boulder, Colorado.

Note: The values shown for Loran-C are in nanoseconds.

		UTC(NIST)-WWVB (60 kHz)	UTC(NIST) - LORAN PHASE (ns)	
DATE	MJD	ANTENNA PHASE (µs)	LORAN-C *(BAUDETTE) (8970-Y)	LORAN-C (FALLON) (9940)
01/01/03	52640	5.72	+193	+397
01/02/03	52641	5.72	+94	−351
01/03/03	52642	5.72	−80	−17
01/04/03	52643	5.72	−67	+101
01/05/03	52644	5.72	+77	+239
01/06/03	52645	5.72	+104	−317
01/07/03	52646	5.72	−11	+118
01/08/03	52647	5.73	−109	−399
01/09/03	52648	5.73	+55	+58
01/10/03	52649	5.73	+256	+141
01/11/03	52650	5.72	+4	+214
01/12/03	52651	5.73	−164	+213
01/13/03	52652	5.73	+105	+254
01/14/03	52653	5.73	−24	−72
01/15/03	52654	5.73	+148	−63
01/16/03	52655	5.73	−162	−322
01/17/03	52656	5.73	+58	+314
01/18/03	52657	5.73	+49	+67
01/19/03	52658	5.73	+13	−83
01/20/03	52659	5.72	+11	+228
01/21/03	52660	5.72	+43	−281
01/22/03	52661	5.73	+62	+36
01/23/03	52662	5.72	−90	−310
01/24/03	52663	5.74	+33	−49
01/25/03	52664	5.74	−122	+189
01/26/03	52665	5.74	+59	−117
01/27/03	52666	5.74	−3	+35
01/28/03	52667	5.73	−39	−101
01/29/03	52668	5.73	−45	−324
01/30/03	52669	5.74	−250	+34
01/31/03	52670	5.74	+75	+239

*NOTE: NIST began monitoring signals from Baudette (8970-Y) at 1900 UTC on May 8, 2001. The change was made to improve the quality of the received signal.

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

WWVB 60 kHz OUTAGES OF 5 MINUTES OR MORE							PHASE PERTURBATIONS 2 ms			
Station	JAN 2003	MJD	Began UTC	Ended UTC	Freq.		JAN 2003	MJD	Began UTC	End UTC
WWVB										
WWV										
WWVH										

5. NOTES ON NIST TIME SCALES AND PRIMARY STANDARDS

Primary frequency standards developed and maintained by NIST are used to provide accuracy (rate) input to the BIPM. NIST-7, which had served as the U.S. primary standard since 1994, has been replaced by NIST-F1, a cesium fountain frequency standard. The uncertainty of the new standard is currently 1.7 parts in 10^{15}.

The AT1 scale is run in real-time using data from an ensemble of cesium standards and hydrogen masers. It is a free-running scale whose frequency is maintained as nearly constant as possible by choosing the optimum weight for each clock that contributes to the computation.

UTC(NIST) is generated as an offset from our real-time scale AT1. It is steered in frequency towards UTC using data published by the BIPM in its Circular T. Changes in the steering frequency will be made, if necessary, at 0000 UTC on the first day of the month, and very occasionally at mid-month. A change in frequency is limited to no more than ± 2 ns/day. The frequency of UTC(NIST) is kept as stable as possible at other times.

UTC is generated at the BIPM using a post-processed time-scale algorithm and is not available in real-time. The parameters that we use to generate UTC(NIST) in real-time are therefore based on an extrapolation of UTC from the most recent data available.

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Table 7.1 lists parameters that are used to define UTC(NIST) with respect to our real-time scale AT1. To find the value of UTC(NIST) – AT1 at any time T (expressed as a Modified Julian Day, including a fraction if needed), the appropriate equation to use is the one for which the desired T is greater than or equal to the entry in the T_0 column and less than the entry in the last column. The values of x_{ls}, x, and y for that month are then used in the equation below to find the desired value. The parameters x and y represent the offset in time and in frequency, respectively, between UTC(NIST) and AT1; the parameter x_{ls} is the number of leap seconds applied to both UTC(NIST) and UTC as specified by the IERS. Leap seconds are not applied to AT1.

Table 7.1

$$UTC(NIST) - AT1 = x_{ls} + x + y \cdot (T - T_0)$$

Month	x_{ls} (s)	x (ns)	y (ns/d)	T_0 (MJD)	Valid until 0000 on: (MJD)
Feb 03	–32	–245474.9	–40.5*	52671	52699
Jan 03	–32	–244906.5	–40.6	52657	52671*
Jan 03	–32	–244218	–40.5	52640	52657†
Dec 02	–32	–243813	–40.5	52630	52640
Dec 02	–32	–242964.6	–40.4	52609	52630†
Nov 02	–32	–242399	–40.4	52595	52609
Nov 02	–32	–241751	–40.5	52579	52595†
Oct 02	–32	–240495.5	–40.5	52548	52579
Sep 02	–32	–240252.5	–40.5	52542	52548
Sep 02	–32	-239274.5	–40.75	52518	52542†
Aug 02	–32	–238577.5	–41.0	52501	52518
Aug 02	–32	-238014.25	–40.25	52487	52501†
Jul 02	–32	-236766.5	–40.25	52456	52487
Jun 02	–32	-236046.5	–40.0	52438	52456
Jun 02	–32	-235560.5	–40.5	52426	52438†
May 02	–32	-234960.5	–40.0	52411	52426
May 02	–32	-234296.5	–41.5	52395	52411†
Apr 02	–32	-233558.5	–41.0	52377	52395
Apr 02	–32	-233072.5	–40.5	52365	52377†
Mar 02	–32	-232829.5	–40.0	52359	52365
Mar 02	–32	–231829.5	–40.0	52334	52359†
Feb 02	–32	–231255.5	–41.0	52320	52334
Feb 02	–32	–230695.5	–40.0	52306	52320†

† Rate change in mid-month
†† Rate change one day early
*Provisional value

7. SPECIAL ANNOUNCEMENTS

TRACEABLE FREQUENCY CALIBRATIONS
(Now NVLAP Certified)

Laboratories can get any needed traceable frequency calibrations by subscribing to the NIST Frequency Measurement and Analysis Service. This service is offered on a lease basis by NIST to provide an easy and inexpensive means to obtain traceability of a laboratory frequency standard and, in addition, to calibrate other devices in the lab. This service has been designed for ease of operation and as a practical calibration tool.

All necessary hardware and software is provided by NIST. Users must provide their own oscillator(s) and an ordinary telephone line so that NIST can access the system by modem. A maximum total of five oscillators can be calibrated at the same time. Radio signals from GPS satellites are used and the measurement uncertainty is $\pm 2 \times 10^{-13}$ per day. Any frequency from 1 Hz to 120 MHz (in 1 Hz increments) can be measured.

The calibration data are displayed in color, and a graph is plotted daily for each oscillator. Data are also stored on disk. The user can call up any of the data and view them onscreen or in the form of plots. Up to 5 months of data can be plotted on one graph.

The system plots are easy to read and understand. The system manual is written clearly and the NIST staff are available by telephone to assist. The modem connection allows NIST to access the data and to prepare a monthly traceability report, which is mailed to the user.

Frequency sources of any accuracy can be calibrated. The FMAS is particularly useful at the highest levels of performance. This is because each user of the system contributes information and calibration data for the others. If an uncertainty arises, it is possible for NIST to call by modem to another user nearby. In this way problems in data interpretation can be resolved.

NVLAP certification requirements for frequency measurement are met by following the NIST-FMAS operating manual. This service does not eliminate the NVLAP audits but, when installed and operated per the NIST guidelines, audit requirements are easily met.

NIST retains title to the equipment and supplies. All necessary replacement parts are replaced by overnight shipment. Training for use of the system is available if requested by the user.

The NIST Frequency Measurement and Analysis Service provides a complete solution to nearly all frequency measurement and calibration problems. For a free information package, please phone Michael Lombardi at (303) 497-3212, or E-mail him at lombardi@boulder.nist.gov, or write to Michael Lombardi, NIST, Division 847, 325 Broadway, Boulder, CO 80305.

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